Physics Flash

August 2016
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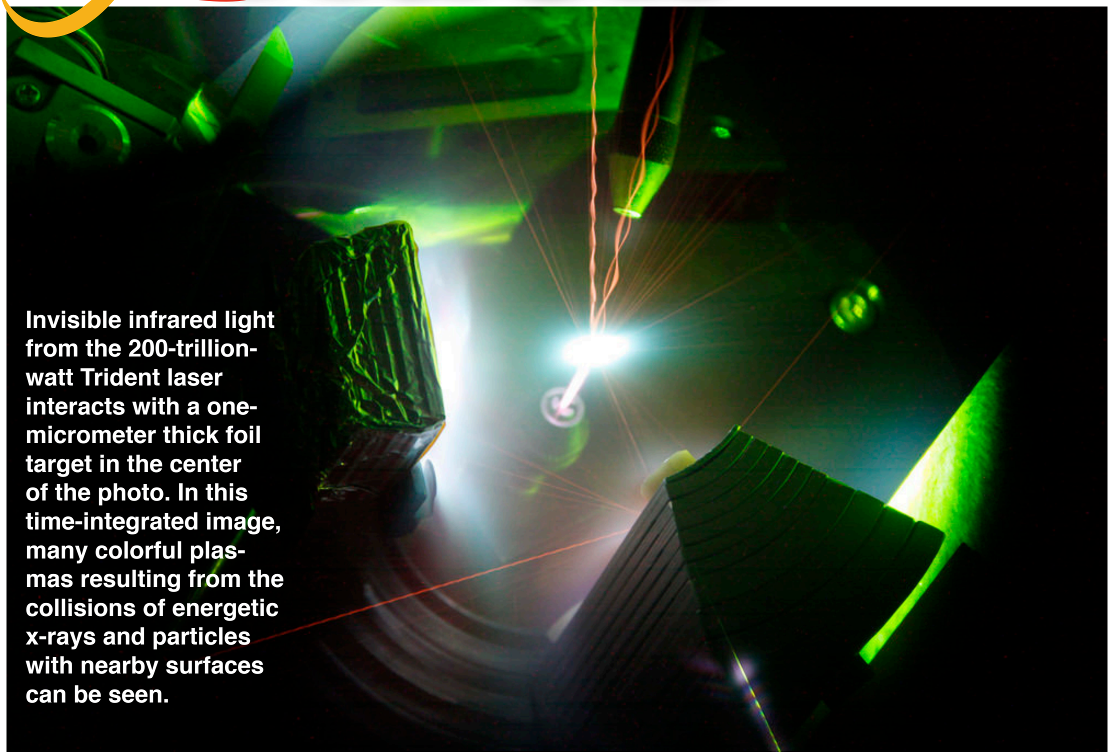
INSIDE

Los Alamos
NATIONAL LABORATORY
EST. 1943



Invisible infrared light from the 200-trillion-watt Trident laser interacts with a one-micrometer thick foil target in the center of the photo. In this time-integrated image, many colorful plasmas resulting from the collisions of energetic x-rays and particles with nearby surfaces can be seen.

Recognizing a scientific workhorse

Trident laser to be retired after 25 years of enabling diverse science in high-energy-density physics and fundamental laser-matter interactions

After more than two decades of service, the Trident Laser Facility will close prior to the end of this fiscal year, Laboratory officials recently announced.

The versatile Trident system has enabled a broad range of experimental science, including experiments in laser-plasma instabilities, material dynamics, diagnostic development, and relativistic laser-matter interaction. Its earliest applications were in support of the Department of Energy's weapons and inertial confinement fusion programs, but over the years, and with the National Ignition Facility coming online at Lawrence Livermore National Laboratory, Trident has been used for increasingly fewer programmatic experiments.

During its decades of use, more than 16,000 laser target shots have been conducted by hundreds of Los Alamos and visiting scientists; more than 150 peer-reviewed journal articles (in 39 different journals) have been published using Trident experimental data; and more than 230 talks have been presented at national and international conferences.

The Trident project was initiated by Robert Gibson (CLS-7) and Bob Watt (P-4) in October 1990, who were tasked with building an x-ray backlighter source for target experiments at the Lab's Aurora Laser. Designs for the laser and associated control systems were completed in early 1991. Large laser amplifiers were obtained from the KMS Fusion Chroma Laser that was being dismantled at that time. New front-end oscillators and amplifiers were purchased and received by the fall of 1991. With the help of several scientists from KMS Fusion, a private sector company, and multiple Los Alamos engineers and technicians, the laser system

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From David's desk . . .

We are more than halfway through summer 2016. I hope that you have been able to take some time off with your families to relax and recuperate. I managed to take eight days in Moab with my wife and son and also we saw our daughter over a long weekend in San Francisco.

Of course, things don't slow down in the summer. We hosted the external High Energy Density Physics and Fluids (HEDP&F) Capability Review in June. This capability is spread through many divisions at LANL, including P, where it is focused primarily in P-23 and P-24. I am very grateful to all of you who participated, making presentations and posters and talking to the committee. I am particularly thankful to my theme leads Melissa Douglas and Kathy Prestridge, who put a great deal of time into the review, to Steve Batha who gave the ICF overview, and to John Sarrao and Mary Hockaday for guiding me through the process. The effort was worth it: the committee was very impressed with our work in this area. In the outbrief they stated, "Our overall finding is that the HEDP&F enterprises are very strong, and that LANL is a world leader in these areas and an attractive place for the best and brightest young scientists to make their careers." The committee submitted their final report that will be distributed after LANL provides its response.

Occasionally I get to do something to support an employee that is completely different than anything I have done before. Mel Borrego is a Research Technologist 2 in P-27, where he supports flight paths and overall facilities during beam operations, and outages in Experimental Areas 1 and 2 and WNR. He is also a Command Sergeant Major for the 111th Special Troops Battalion that carries out policies and procedures, sets standards of performance, training, appearance, and conduct of enlisted personnel. As part of the National Guard's Employer Support of the Guard and Reserve program, I was invited to participate in its annual Boss Lift. Employers from around New Mexico were represented. We learned about their weaponry and their HazMat capabilities. The highlight was a real "lift," a ride in a Blackhawk helicopter (see figure). I will always try to be available to support any employee of the division.

As I hope that you all know, W. Scott Wilburn has transitioned to a new position at LANL, XTD Deputy Division Leader. I wish him the best in his new position and am very thankful for all of the support he gave me and the division during his tenure. I will be developing a plan to fill my deputy division leader position.

Finally, when you read this, it will be just past my first anniversary as Physics Division Leader. It has been a wonderful year. I have greatly enjoyed getting to know you and to learning about what all of you do. I am looking forward to the next challenges and opportunities that I will face as Physics Division Leader.

Physics Division Leader
David Meyerhofer

The helicopter that David rode in during the Boss Lift.
(courtesy D.D. Meyerhofer)

"It has been a wonderful year. I have greatly enjoyed getting to know you and to learning about what all of you do. I am looking forward to the next challenges and opportunities that I will face as Physics Division Leader."

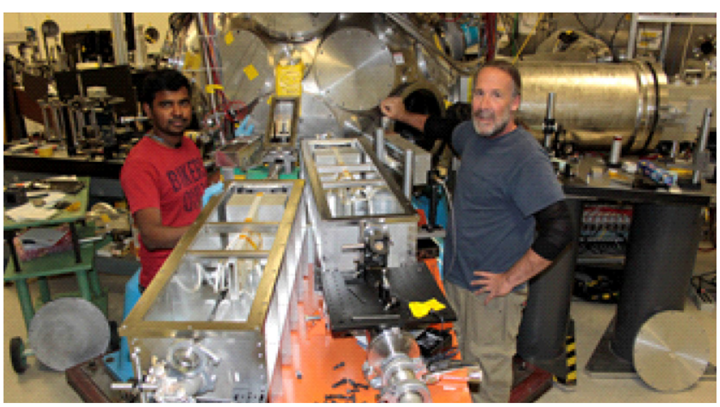
David

Trident cont.

was assembled and tested with initial target shots beginning in September 1992.

To diagnose experiments at the Aurora Laser Facility, located next door, Trident's initial design included producing 100 J in 100 ps to create a short pulse of x-rays. When the Trident Facility had completed its first target shots, the Aurora Laser was being dismantled. In response, the Trident front end was upgraded to allow shaping of pulses in the range from 100 ps–2 ns, allowing inertial confinement fusion-related experiments to be conducted at the facility. Scientists studying materials dynamics expressed the need for longer laser pulses, so an oscillator capable of producing pulses in the range from 10 ns–10 ms was developed. Likewise, as interest increased in short-pulse, high-intensity experiments, oscillators and optics were installed to produce high-energy pulses of less than 1 ps. The system ultimately effectively produced shaped laser pulses from 600 fs (100 J)–10 ms (1000 J), with peak focused intensity on target greater than 10^{21} W/cm^2. The Trident short pulse system uses a unique "pulse cleaning" device to eliminate pre-energy that would destroy thin targets before the high-intensity pulse arrives. This innovation allowed high-intensity target experiments using ultra-thin targets (10–500 nm thick), which produced world-record laser ion acceleration results.

"Trident has been a great scientific contributor for the past two decades," said Mary Hockaday, associate director for Experimental Physical Sciences (ADEPS). "This is a decision we wrestled with greatly, but the reality is that there are other, higher priorities for the weapons program and the funding available through the remaining sponsors is not enough to continue to operate Trident." Hockaday said that Los Alamos may consider exploring opportunities for Trident at other facilities where the still-capable laser system could have a home. Trident has great flexibility for shaping the pulse of laser energy to optimize it for different research applications.



Sasi Palaniyappan and Cort Gautier (Plasma Physics, P-24) field particle beam diagnostics on the north target chamber.

Accomplishments in the Trident Laser Facility

Trident has been an extremely productive research facility. More than 150 peer-reviewed journal articles (39 different journals) have been published using Trident experimental data, with more than 5000 citations in the literature. At least 23 Los Alamos postdoctoral researchers worked on Trident. It had approximately 20 unique users from more than 30 unique institutions worldwide. At least 20 PhD students did a significant

To read the full article, see "Trident.accomplishments.lanl.gov"

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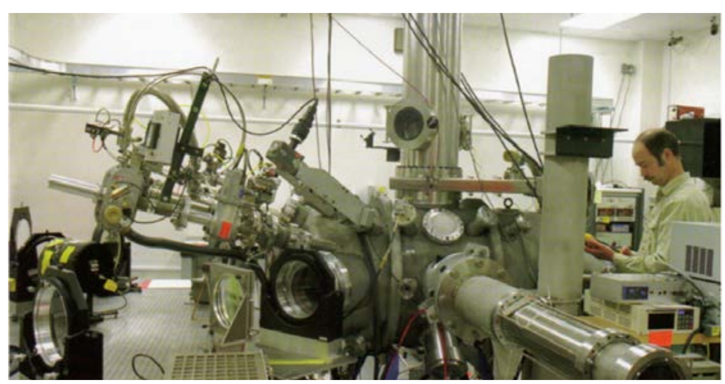
Robert Gibson receives the first Trident component from Kent Moncur of KMS Fusion, Inc.

Fred Archuleta (retired) maintains Trident beamlines.



Tom Hurry (retired) prepares for a target shot in the south target chamber.

Accomplishments cont.

fraction of their thesis work on Trident. This research has supported the Los Alamos Inertial Confinement Fusion and Weapons research programs and has advanced technologies and techniques that hold promise for Los Alamos initiatives, such as MaRIE, the Laboratory's proposed experimental facility for the study of matter-radiation interactions in extremes.

A few specific research contributions based on Trident experiments are:

- First demonstration of laser-driven quasi-monoenergetic ion beams (Al and C) with simultaneously high ion-energy and high efficiency
- Demonstration of the highest yield laser-driven neutron beam fluence to date: > 10^{10} neutrons within ~ 1 steradian, created in ~ 1 ns
- First laboratory demonstration of relativistically induced transparency (RIT)
- Characterization and development of laser-driven ion acceleration in the RIT regime, especially the novel breakout afterburner mechanism
- First direct and comprehensive characterization of the ion acoustic waves driven to high levels by stimulated Brillouin scattering (SBS), using Thomson scattering measurements
- First demonstration that backward stimulated-Raman backscatter (SRS) in ignition-relevant plasmas, even with controlled, diffraction-limited (single-hot-spot) laser beams in homogeneous plasma conditions, has a nonlinear onset and saturation
- First measurements with sufficient sensitivity to discriminate between diffusion bonded and press fit Cu/Be dynamic friction model parameters under shock-driven sliding conditions
- First in situ measurements of full-field shock planarity at 10s nm sensitivity using transient imaging displacement interferometry under plate impacts driven by gas guns and by lasers
- Measurement of blast waves showing the transition from stability to Vishniac instability depending on the adiabatic index of the propagation medium

Celebrating service

Congratulations to the following Physics Division employees celebrating service anniversaries recently:

Stephen Wender, P-27	35 years
William Buttler, P-23	25 years
Chris Frankle, P-23	25 years
Martin Schauer, P-21	25 years
Brenda Dingus, P-23	15 years
Matt Durham, P-25	5 years
Kun Liu, P-25	5 years

David Meyerhofer elected as chair-elect APS Nominating Committee

The American Physical Society (APS) has elected David Meyerhofer (Physics Division Leader, P-DO) to be the chair-elect of the Nominating Committee. The chair-elect serves a one-year term, followed by a one-year term as chair, followed by a one-year term as the most recent past chair.

The American Physical Society is a non-profit membership organization formed in 1899. It works to advance and diffuse the knowledge of physics. APS represents more than 51,000 members, including physicists in academia, national laboratories, and industry in the United States and throughout the world. The Nominating Committee prepares a slate of at least two candidates for each of the positions of vice president, treasurer, chair elect of the Nominating Committee, and the vacant positions of general councilor and international councilor. The Nominating Committee also prepares a slate of candidates for other positions specified by the board or the council.

Technical contact: David Meyerhofer

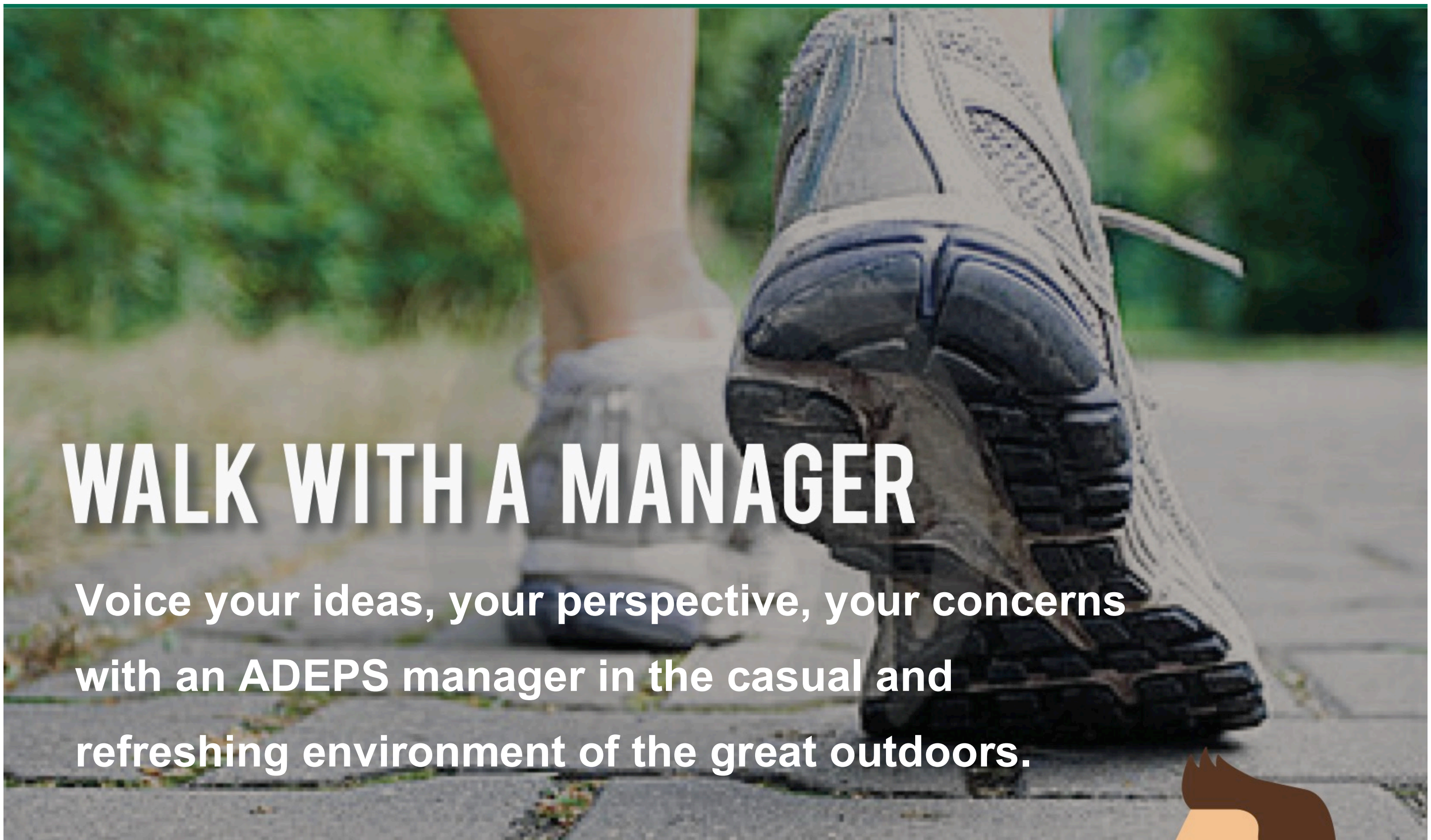
HeadsUP!

Using cell phones while operating government vehicles is prohibited

Lab employees are reminded that Lab Policy P101.7 Vehicle and Pedestrian Safety, prohibits the use of cell phones while operating government vehicles. Specifically, Section 3.2 of the policy states in part: "Workers must not use cellular phones and similar electronic devices or perform other distracting activities while operating government vehicles. These activities should only be performed when the vehicle is safely stopped or parked. ..."

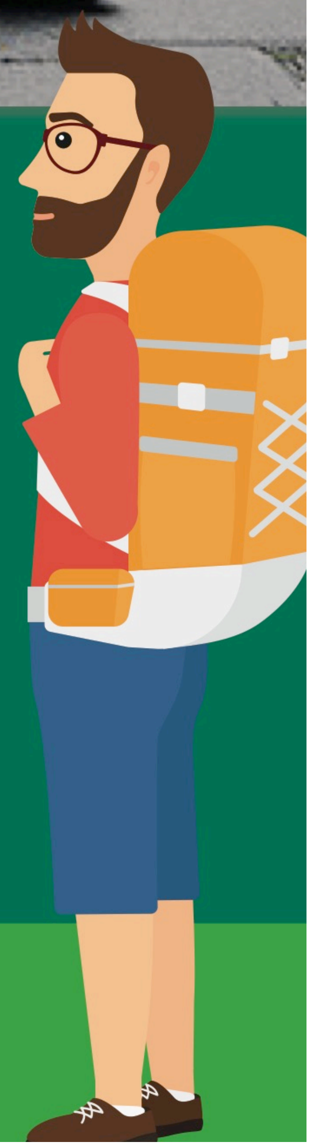
Most Lab hiking trails reopened

Due to a significant drop in the number of bear sightings and encounters the Laboratory is reopening most trails on its property. Five trails on Laboratory property will remain closed due to safety or environmental reasons, all others will be open. The closed trails include three of the Los Alamos Canyon trails (Hidden Canyon, Deadman Crossing and Devaney/Longmire) and two of the Mortandad Canyon trails (Bench and Canyon). For detailed information on Lab trails go to www.lanl.gov/trails.



WALK WITH A MANAGER

Voice your ideas, your perspective, your concerns with an ADEPS manager in the casual and refreshing environment of the great outdoors.



During the months of August and September, ADEPS managers are available to staff interested in getting together for informal walking and talking meetings.

The event is part of the directorate’s health and wellness initiative aimed at promoting a healthy, safe, and productive workforce.

Nothing is off the table; topics are yours to decide.

So don your sensible shoes, bring a water bottle, and walk with a manager!

To make an appointment, contact the following:
ADEPS: Tina Varela, cvarela@lanl.gov, 665-4454
MPA: Susie Duran, susiew@lanl.gov, 665-1131
MST: Monica Roybal, mgr@lanl.gov, 665-1535
P: Gerri Barela, gbarela@lanl.gov, 667-4117
SIGMA: Brenda Espinoza, bme@lanl.gov, 667-4368

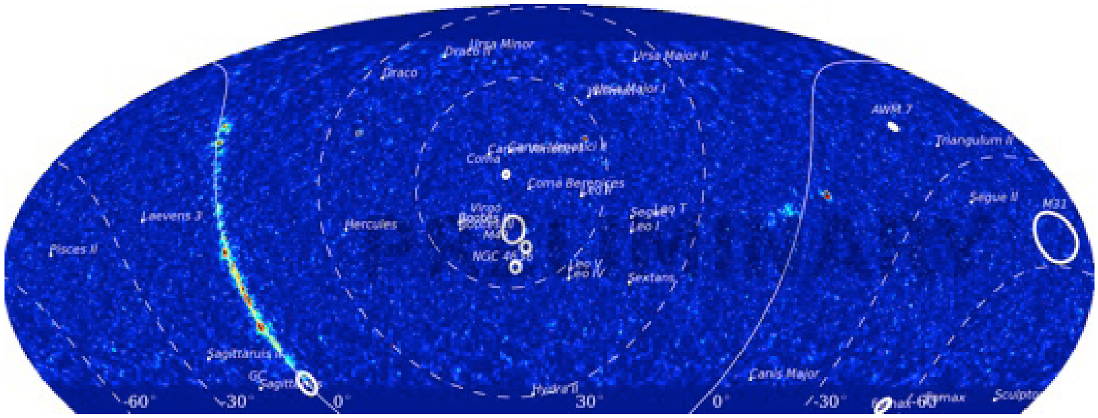
HAWC searches for gamma rays from dark matter

Results from first year of data collection constrain some theoretical models

Researchers with the High Altitude Water Cherenkov (HAWC) Gamma-Ray Observatory, a joint project of Los Alamos National Laboratory and universities in the United States, Mexico, Poland, and Germany, have released results of the first year of data collection with the full observatory. Located 13,500 feet above sea level on Volcán Sierra Negra in Puebla, Mexico, the HAWC observatory is sensitive to the highest-energy gamma rays ever observed. These photons point back to their astrophysical sources, allowing the scientists to determine whether a given source produces such high-energy gamma rays.

One of the HAWC science goals, led by the team at the Laboratory, is to search for gamma rays coming from regions of dark matter in space. The nature of dark matter means that it does not typically emit photons. However, it is theorized that two dark matter particles could annihilate one another to produce a signal of gamma rays. Gamma rays could also be produced if the dark matter particles are unstable and decay. The HAWC detector is looking for gamma rays from these processes to verify if gamma rays are, in fact, produced by dark matter.

The HAWC detector sees more than two-thirds of the sky, so it has the ability to observe many different dark matter targets, such as dwarf satellite galaxies, across the sky. HAWC, probing these regions with



The HAWC one-year skymap, released at the 2016 American Physical Society April Meeting, shows the dark matter target regions overlaid as white circles. There are more than 20 known regions of high dark matter density within HAWC's field-of-view.

unprecedented sensitivity at the highest energies, did not see any excess of photons. This non-detection constrains some theoretical models, which predicted HAWC would observe a clear excess of photons in these regions. HAWC continues taking data, and its sensitivity will improve over the next few years, allowing it to test more theories of dark matter.

The National Science Foundation, the Department of Energy Office of Science, and Los Alamos National Laboratory (through the Laboratory Directed Research and Development program) provided funding for the United States' participation in the HAWC project. The Consejo Nacional de Ciencia y Tecnología is the primary funder for Mexican participation.
For more information on HAWC, please see www.hawc-observatory.org.

The work supports the Laboratory's Experimental Physical Sciences mission area and the Nuclear and Particle Futures science pillar by increasing our understanding of high energy and plasma physics and astrophysics and by developing expertise and capabilities in particle detection, data acquisition systems, and big data analysis.

Technical contact: Pat Harding

Proton Radiography Facility commissions electromagnetic magnifier

A new set of magnets at the Proton Radiography Facility (pRad) at Los Alamos Neutron Science Center (LANSCE) has improved the reliability and predictability of this important capability for imaging dynamic experiments in support of weapons science and stockpile stewardship programs.

Invented at Los Alamos National Laboratory, proton radiography uses a high-energy proton beam from the LANSCE accelerator to image the properties and behavior of materials under a variety of conditions. The penetrating power of high-energy protons makes them an excellent probe of a wide range of materials under extreme pressures, strains, and strain rates. The pRad capability has revolutionized dynamic materials science at the Laboratory, providing a new window for the study of shock physics, materials damage, and high explosives science.

The team replaced the permanent magnet quadrupoles (PMQ), which can demagnetize due to radiation damage. Even with the Lab's in-house re-magnetization capabilities, this was a serious limitation, especially for experiments that require high beam doses such as the series of "solidification" experiments and tomography of static object. The new EX3 magnifier consists of four quadrupole magnets, four power supplies, mounting structure, and water cooling.

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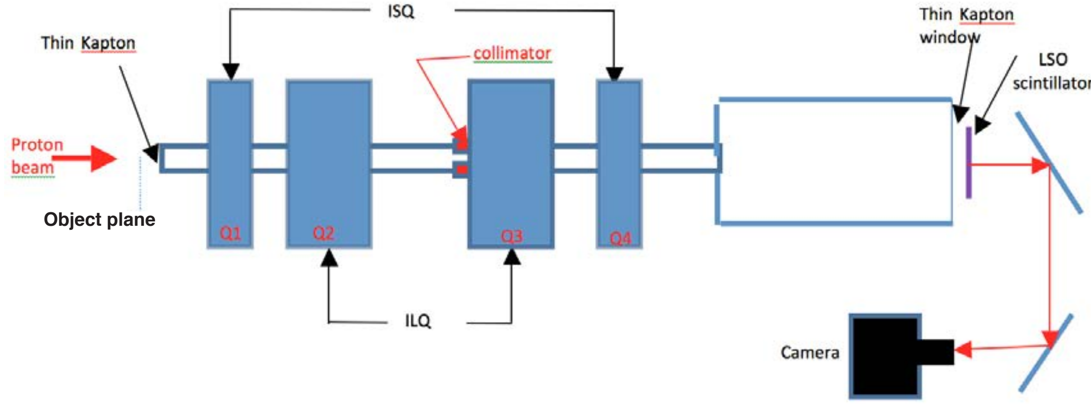
Commissions cont.



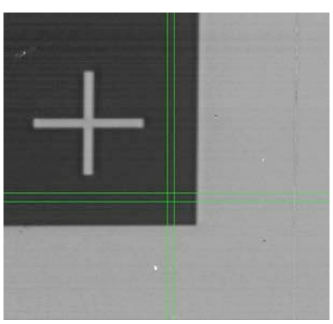
Schematic diagram of the pRad beam line setup. Two types of cameras with different pixel resolution acquire data. An image plate at the lutetium oxyorthosilicate (LSO) scintillator position acquires a high-resolution image.

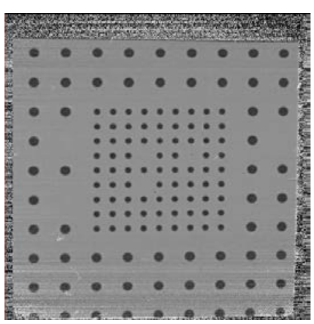
The figure depicts the layout. Beam line simulations indicate that the short quadrupoles Q1 and Q4 can, in principle, be connected to one power supply in series (ISQ); the same applies for the long quadrupoles Q2 and Q3 (ILQ). For the first tests, the researchers connected each magnet to its own power supply to provide additional flexibility in tuning the system.

Images of standard pRad tuning objects determined rough focus quadrupole settings for the new system. For example, a 3-mm-thick tungsten resolution plate measured system edge resolution. Other tests confirmed the presence of a small rotational misalignment, which the team corrected. The researchers performed a final focus scan by changing the magnet currents according to a method that they had developed using beam-optic simulations.

During the current shutdown period, the team will complete permanent installation of the EX3 in the pRad dome. Based on lessons learned during the commissioning phase, they will modify existing subcomponents and incorporate new hardware—such as more precise magnet current monitoring instrumentation. The team will require about three days of beam early in the next run cycle to check the system once more before formally declaring it ready for dynamic experiments.

The following people contributed to the success of the project: John Goett II, Frank Merrill, Paul Nedrow, Josh Tybo, and Carl Wilde (Neutron Science and Technology, P-23); Matt Freeman, Brian Hollander, Julian Lopez, Fesseha Mariam, Michael Martinez, Jason Medina, Patrick Medina, Chris Morris, Debbie Morley, Matthew Murray, Levi Neukirch, Andy Saunders, Thomas Sisneros, Amy Tainter, Frans Trouw, and Dale Tupa (Subatomic Physics, P-25); Eric Larson (LANSCE Weapons Physics, P-27); James O'Hara and team (Mechanical Design Engineering, AOT-MDE); David Barlow, Joe Bradley, and team (Radio Frequency Engineering, AOT-RFE).





(Left): Image of a corner of the tungsten resolution plate. The cross is a 0.5-mm cutout and is 6 mm x 6 mm. (Right): Image of a fiducial plate. The black circles are small disks of tungsten imbedded in a plastic substrate. The spacing in the inner cluster is 2.5 mm; the outer ones are 5 mm apart. The image shows that the field of view of the imaging system is about 4 cm x 4 cm.

Institutional PADSTE G&A Science Investment funded the work, which supports the Lab's Nuclear Deterrence mission area and the Materials for the Future and Science of Signatures science pillars.

Technical contact: Fesseha G. Mariam

Cosmic ray muon computed tomography of spent nuclear fuel in dry storage casks

Radiography with cosmic ray muon scattering has proven to be a successful method of imaging nuclear material through heavy shielding. Monitoring spent nuclear fuel sealed in dry storage casks is of particular interest to international safeguards. These casks are heavily shielded to prevent radiation leakage to the environment, which precludes monitoring using typical radiographic probes such as neutrons or photons.

Subatomic Physics (P-25) researchers and collaborators demonstrated a novel approach to imaging these casks by applying computed tomography algorithms typically used in medical imaging to cosmic ray muon imaging. With a cylindrical muon tracking detector surrounding a typically spent fuel cask, the researchers demonstrated that cask contents can be confirmed with high confidence with less than two days exposure.

Their technique, which fulfills an NA-22 milestone and solves a three-decades-old safeguard challenge, shows that the diversion of spent fuel assemblies can be determined without opening the cask and on a time scale well within the

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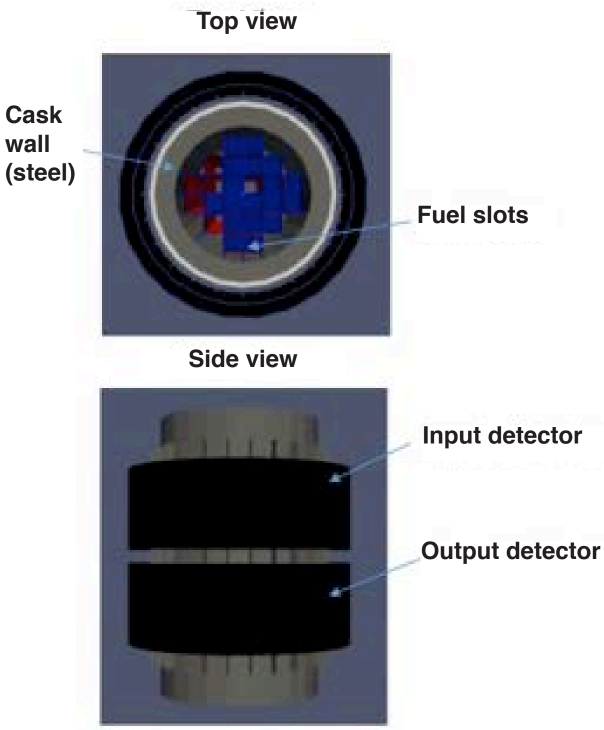
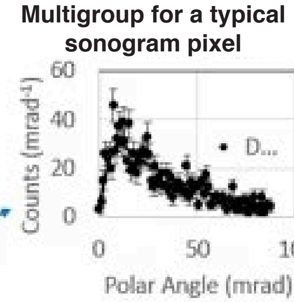
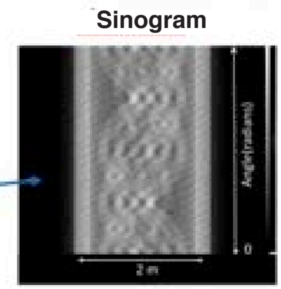
Cosmic ray cont.



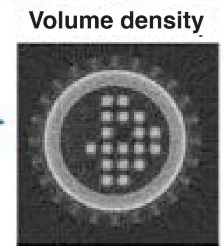
- **Generate trajectory through the cask with GEANT. About 1 day of exposure.**
- **Make a histogram of scattering angle for each pixel in a sonogram. Integrate in the vertical direction.**



- **Fit the scattering angle distribution to get the areal density using the calibrated multigroup method. Enter into a 3D histrogram.**



- **Apply filtered back projection to obtain a cross section in scattering length density. Empty slots are visible with 20 σ significance.**



International Atomic Energy Agency timeliness goals. This technique and a dedicated instrument could be a useful tool for international nuclear safeguards inspectors. Technology options to construct such a detector are being explored. The researchers demonstrated the feasibility of their technique using GEANT4 simulations of cosmic ray muons passing through a cylindrical muon tracking detector around a partially loaded Westinghouse MC-10 cask. Images of the cask interior were reconstructed using a filtered back-projection algorithm. Previous muon radiography measurements on a fuel cask used drift tube tracking detectors to measure the areal density between the two detectors. This showed that missing fuel assemblies could be located, but the single measurement of integrated density left ambiguity in the exact location of the missing fuel elements in the direction orthogonal to the two detectors. Using a cylindrical detector fitting around the outside of the cask not only increases the detector's active area, but also enables simultaneous measuring of muon scattering through all azimuthal angles of the cask. With this continuum of areal density measurements, computed tomography image reconstruction algorithms can be applied to produce full images of the cask interior.

This work, which is funded by the National Nuclear Security Administration's Office of Defense Nuclear Nonproliferation Research & Development, (LANL Program Manager Roger Petrin), supports the Laboratory's Global Security mission and Science of Signatures pillar. Researchers are Daniel Poulson (P-25 and University of New Mexico, Albuquerque); J. Matthew Durham, Elena Guardincerri, Christopher L. Morris, Jeffrey D. Bacon, Kenie Plaud-Ramos, and Deborah Morley (P-25); and Adam Hecht (University of New Mexico, Albuquerque). Preliminary results, J. M. Durham et al, "Cosmic Ray Muon Imaging of Spent Nuclear Fuel in Dry Storage Casks," are scheduled for publication in the *Journal of Nuclear Materials Management*.

Technical contact: Chris Morris

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To submit news items or for more information, contact Karen Kippen, ADEPS Communications, at 505-606-1822, or adeps-comm@lanl.gov.

For past issues, see www.lanl.gov/org/padste/adeps/physics/physics-flash-archive.php

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